PB 185967

REPORT OF PRELIMINARY MEASUREMENTS OF ELECTROMAGNETIC RADIATION FIELDS NEAR MICROWAVE OVENS

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration

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TSB NO. 5

REPORT OF PRELIMINARY MEASUREMENTS OF ELECTROMAGNETIC RADIATION FIELDS NEAR MICROWAVE OVENS

TECHNICAL SERVICES BRANCH

Staff Report

by

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December, 1968

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration
National Center for Radiological Health
Rockville, Maryland 20852

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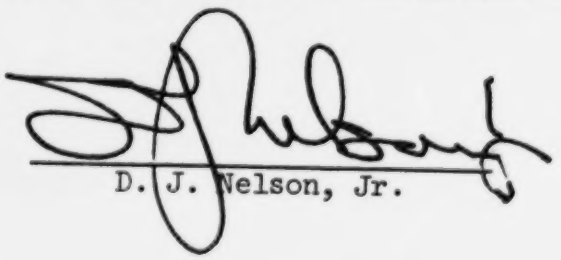
FOREWORD

Microwave ovens are now being sold for domestic use in increasing numbers. The ovens should be designed to prevent the propagation of potentially harmful electromagnetic energy fields outside the oven under expected conditions of operation in the home. The nature and level of these emissions must be better understood to evaluate their health significance and to protect the consumer.

This report presents preliminary data on electromagnetic radiation power density measurements near operating microwave ovens currently on the market. The reported power density levels were obtained from existing commercial instrumentation for which a far field calibration only was available. Preliminary indications are that refinement in the calibration of instrumentation would increase the reported microwave power density values. Microwave exposure levels under various modes of safety-feature failure were determined. Commercially available power measuring instruments were compared on the basis of readings made in front of an oven operated with the door open.

Domestic ovens were consigned to the Electronic Products Radiation Laboratory, National Center for Radiological Health for test purposes by the manufacturer, with the assistance of the Association of Home Appliance Manufacturers.

Further testing is envisioned, based upon findings in this report, which will enable the development of improved instrumentation and procedures for the continued evaluation of the potential exposure of the public to microwave energy from these electronic consumer products.



D. J. Nelson, Jr.

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Report of Preliminary Measurements of Electromagnetic Radiation Fields Near Microwave Ovens

by:

D. L. Solem, D. G. Remark, R. L. Moore,
R. E. Crawford, and H. J. L. Rechen

SUMMARY

A microwave oven from each of five different manufacturers was tested in an anechoic microwave chamber to determine the electromagnetic radiation exposures which would be encountered if safety devices failed. Commercially available instruments indicated power densities greater than 700 milliwatts per square centimeter at 30 cm (12 inches) in front of an oven with the door open, and power densities of 10 mW/cm^2 at 120 cm (48 inches) from the ovens.

The safety interlock switches were examined to determine how they operated and how they could be defeated. In all cases except one, the operation of the safety interlocks relied solely on spring powered switches to prevent the generation of microwaves when the oven doors were opened. In one case, a safety interlock was used which utilized the operation of the door latch to inactivate the microwave generation system. In one oven it was possible for a person to manipulate the interlock system without tools to permit the generation of microwave power with the door open.

The response of three commercially available microwave power measuring instruments were compared in the microwave field produced by an oven. It was found that the near-field maxima and minima did not coincide either in amplitude or location, and that far-field measurements of power density agreed only to within a factor of 12 (10.8 dB) among the different instruments.

A failure of the door microwave energy seal was simulated for each oven, and the resulting microwave radiation leakage was observed with one of the commercial instruments.

INTRODUCTION

Increasingly, microwave cooking ovens are becoming popular in commercial and domestic establishments, and a potential microwave exposure hazard exists for persons using, testing or repairing these devices. For this reason, a study of microwave ovens was initiated at NCRH. One purpose of this study was to determine the levels of microwave energy to which people may be exposed if the safety devices on the ovens fail or are defeated. A second purpose was to observe the response of three commercial microwave survey instruments when exposed to the microwave field emitted through the open door of an oven.

Microwave power density measurements performed on microwave ovens in service have revealed radiation leakages above those allowed in published standards and criteria for human exposure by some government agencies and industry.[1,2,3,4] Much higher power densities can occur in

front of an oven when safety interlocks fail or are bypassed, and the oven operates with the door open. Domestic users or service personnel may modify these safety interlocks for convenience of repair or operation.[1]

The ovens, as electromagnetic radiation generators, operating at 1 kilowatt are subject to Federal Communications Commission rules and regulations with regard to frequency control. The regulations do not limit the amount of microwave radiation generated by the oven within the allocated frequencies.

This preliminary study has attempted to evaluate the levels of microwave radiation at various locations in front of the ovens under simulated conditions of total safety interlock failure. The microwave power levels were measured with the oven doors partially and fully open and for different oven load configurations.

To make the test measurements, it was necessary to defeat the interlocks and safety devices so that the microwave oven would operate with the door open. Ideally, a safety interlock should always use the action which can result in damage, such as opening the oven door, to directly block or prevent the operation of the damage producing mechanism. The types of interlock features on each of five brands of microwave ovens were examined to determine if safety action was accomplished by an indirect action such as a spring return, or by a direct mechanical action which renders the oven safe, for example, by opening the door or operating

a latch prior to opening the door. Switches were examined to see if food spills could easily cause sticking or short circuiting.

The response of three commercially available microwave power-measuring instruments were compared in the microwave field produced by an oven. The conditions of measurement were identical for each instrument.

SOURCE OF MICROWAVE OVENS

The Association of Home Appliance Manufacturers arranged to have each of the four manufacturers of microwave ovens designed for home use consign one of their units to the NCRH for testing.

One commercial unit commonly used for reheat of foods in public snack bars was purchased and also used in the tests. Oven model numbers, serial numbers and other features of construction are included in Appendix 1.

EXPERIMENTAL PROCEDURE AND DATA

The microwave oven to be tested was placed in an anechoic chamber (Appendix 2) with the oven opening about 14 feet from the chamber opening. The three oven units, that were not incorporated into a complete range, were placed on a $2\frac{1}{2}$ foot high wooden table. Three of the ovens have a "hi-lo" switch which controls the power input to the magnetron. This is used to select the power level supplied into the cooking cavity and thereby allows a shorter or longer cooking time. All measurements were made with the switch in the high power position, where the effective microwave cooking power is about one kilowatt.

The instruments and equipment used for radiation measurements are listed in Appendix 3. All instrument readings have been converted to mW/cm^2, based on far field power density calibrations supplied by the manufacturer.

Interlock Examinations and Failure Tests

In this test the oven door safety interlocks were completely bypassed and electrical jumpers installed so that the oven could be remotely operated. A "standard load" was chosen to be 250 ml of water in a 250 ml Pyrex glass beaker, placed in the center of the oven-heating cavity, on the oven shelf. Power density readings were taken with a Ramcor 1200B Densiometer using any necessary attenuation and a method of external readout. Microwave anechoic material was used to reduce reflections from everything except the antenna itself. Because the horn antenna used on the Ramcor for 2450 MHz is sensitive to the polarization of the microwave field, two readings were taken at each location: one reading with the long dimension of the opening of the horn antenna vertical and the second at right angles to the first. The Ramcor antenna, used for the 915 MHz operating frequency of the GE oven, is a dipole arranged in a spiral and is relatively insensitive to field polarization effects.

Some ovens used a stirrer, a mechanical device intended to distribute microwave energy more uniformly throughout the oven cavity, or to rotate the oven load for more uniform absorption of microwave energy. The stirrers produced fluctuations in power density readings at the

measurement points. A maximum and a minimum reading were recorded where the effect of the stirrer was apparent.

Measurements were made at seven locations, five at 60 cm from the plane of the oven opening, one at 120 cm and one at 30 cm as shown in Figure 1. At each location, readings were taken with each of the two antenna positions when the oven door was fully open, opened 45° and opened 2.5 cm from the closed position. Measurement data for each oven are presented in Tables 1 through 5.

Procedures for defeating the safety interlocks were developed for each oven. In one case the oven interlocks could be defeated by a single individual, manually, without the use of tools or equipment.

A piece of clear plastic 2.5 cm x 6.3 cm x 0.76 mm (0.030 in.) was placed in the oven door seal to induce radiation leakage. The interlocks and doors were not modified for this test and the ovens were in their "as received" condition. The standard test load of 250 ml of water was placed at the cavity center. Instrument readings were made with a Ramcor 1200B Densiometer held at a distance of 5 cm from the nearest surface of the oven to the nearest point of the instrument antenna. In all cases it was possible to produce microwave leakage, although this did not always occur at the location of the shim. The maximum readings with the shims in place are given in Table 6.

Fig. No. 1. Locations for Microwave Power Measurements
for
Total Interlock Failure Tests

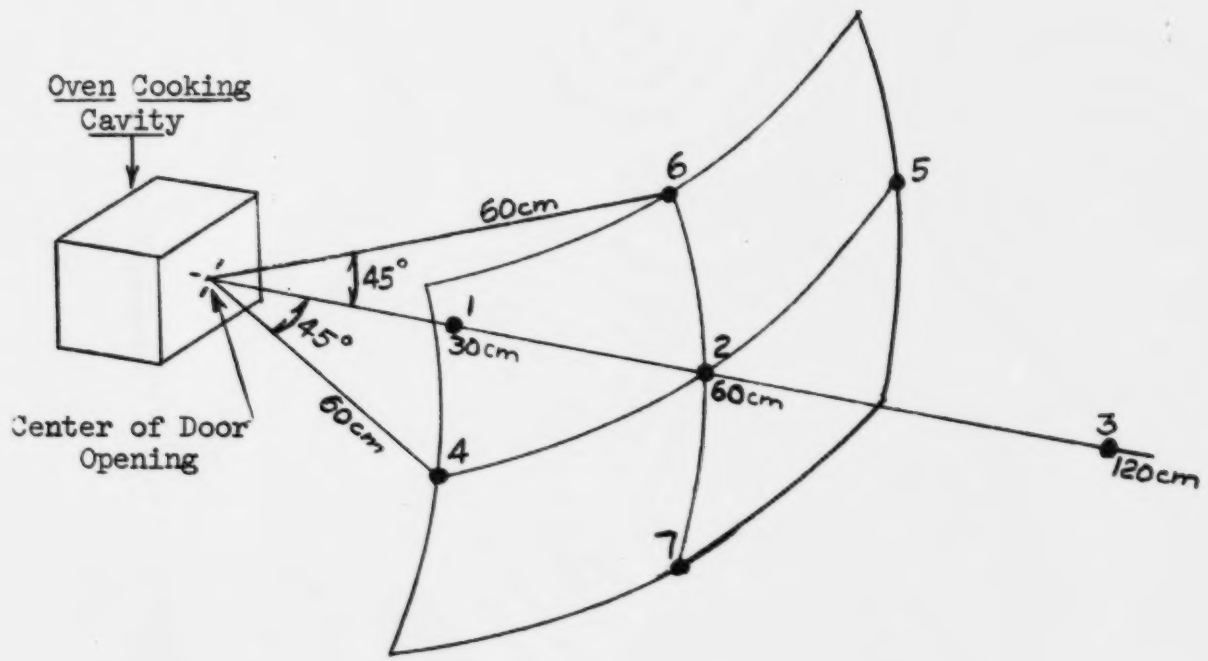


Table No. 1

Power Density Measurements in mW/cm^2
(Interlocks Defeated)

Litton Model 500
Operating frequency 2450 MHz

Location No.*	Antenna Position**	Door Fully Open		Door 45° Open		Door 2.5 cm Open	
		max.	min.	max.	min.	max.	min.
1	V	72	42	19	16	2	--
	H	775	500	3	--	3	--
2	V	17	6	18	8	--	--
	H	250	200	3	--	3	--
3	V	4	1	1	--	--	--
	H	21	18	4.5	2	--	--
4	V	8	5	5	2	--	--
	H	3	1	3	1	3	1
5	V	70	20	60	50	1	--
	H	165	77	250	190	2	--
6	V	80	50	60	45	4.5	4
	H	600	500	300	200	6	4
7	V	72	30	5.5	4.5	4.5	4
	H	110	50	21	10	4.5	3

A dash indicates that the reading was less than 1 mW/cm^2.
Measurements were made with a Ramcor Model 1200B Densiometer with an S band horn antenna and appropriate attenuators.

* Refer to Figure No. 1.

** H indicates that the long axis of the antenna horn opening is horizontal, V indicates that the long axis of the antenna horn opening is vertical.

Table No. 2

Power Density Measurements in mW/cm^2
(Interlocks Defeated)

General Electric Versatronic Model JE896D1AV

Operating frequency 915 MHz

Location No.*	Door Fully Open		Door 45° Open		Door 2.5 cm Open	
	max.	min.	max.	min.	max.	min.
1	105	42	--	--	--	--
2	100	60	16.8	7.75	--	--
3	16.5	6.5	3	--	--	--
4	53	42	39	28	1	--
5	160	135	44	38	3	2
6	33	6	4	1	2	1
7	7.75	7	2	1	--	--

A dash indicates that the reading was less than 1 mW/cm^2. Measurements were made with a Ramcor Model 1200B Densiometer with an L band antenna and appropriate attenuators. The L band antenna used for the 915 MHz operating frequency of this oven was non-polarized and only one reading was made at each position.

* Refer to Figure No. 1.

Table No. 3

Power Density Measurements in mW/cm^2
(Interlocks Defeated)

Sears Kenmore Electronic Model 994

Operating frequency 2450 MHz

Location No.*	Antenna Position**	Door Fully Open	Door 45° Open	Door 2.5 cm Open
1	V	120	45	5
	H	490	10	66
2	V	190	17	5
	H	168	7	13
3	V	17	5	1
	H	19	5	4
4	V	1	10	5
	H	5	18	6
5	V	140	195	3.5
	H	240	330	6
6	V	75	70	4.5
	H	160	55	17
7	V	500	85	4.5
	H	190	100	48

A dash indicates that the reading was less than 1 mW/cm^2.
Measurements were made with a Ramcor Model 1200B Densiometer with an S band horn antenna and appropriate attenuators.

* Refer to Figure No. 1.

** H indicates that the long axis of the antenna horn opening is horizontal, V indicates that the long axis of the antenna horn opening is vertical.

Table No. 4

Power Density Measurements in mW/cm^2
(Interlocks Defeated)

Amana Radarange Model RR-1

Operating frequency 2450 MHz

Location No.*	Antenna Position**	Door Fully Open	Door 45° Open	Door 2.5 cm Open
1	V	12	1	--
	H	775	3	--
2	V	22	4	--
	H	180	17	--
3	V	16	1	--
	H	33	6	--
4	V	69	23	--
	H	120	15	--
5	V	50	17	--
	H	180	70	--
6	V	62	66	--
	H	170	20	--
7	V	--	--	--
	H	1.5	--	--

A dash indicates that the reading was less than 1 mW/cm^2.
Measurements were made with a Ramcor Model 1200B Densiometer with an S band horn antenna and appropriate attenuators.

* Refer to Figure No. 1.

** H indicates that the long axis of the antenna horn opening is horizontal, V indicates that the long axis of the antenna horn opening is vertical.

Table No. 5

Power Density Measurements in mW/cm^2
(Interlocks Defeated)

Tappan Electronic Model R-4A

Operating frequency 2450 MHz

Location No.*	Antenna Position**	Door Fully Open	Door 45° Open	Door 2.5 cm Open
1	V	190	2	8
	H	450	3	7
2	V	120	6	7
	H	190	68	--
3	V	33	6	4
	H	20	20	4
4	V	110	74	10
	H	470	40	8
5	V	150	53	14
	H	180	65	8
6	V	160	170	7
	H	160	200	18
7	V	2	4	6
	H	4	4	4

A dash indicates that the reading was less than 1 mW/cm^2.
Measurements were made with a Ramcor Model 1200B Densiometer with an S band horn antenna and appropriate attenuators.

* Refer to Figure No. 1.

** H indicates that the long axis of the antenna horn opening is horizontal, V indicates that the long axis of the antenna horn opening is vertical.

Table No. 6

Maximum Microwave Power Densities with Shimmed Door, in mW/cm^2

	Reading mW/cm^2
Litton	10
GE	5
Sears	4
Amana	1
Tappan	17

Variation with Line Voltage

The effect of the variation of AC line voltage on the generation of microwave radiation fields is shown in Table 7. The voltage was varied with a General Radio "Variac" Type 50B. Tests were conducted using a beaker containing 250 ml of water placed in the center of the cooking cavity as the load. The oven door interlocks were defeated and the oven door was completely open. The measurements were taken with a Ramcor 1200B Densiometer using a 10 dB attenuator with the long axis of the S-band horn, where used, in a horizontal position. The point of measurement was 60 cm from the oven face, at a height equal to that of the center of the cavity.

Variation with Load Placement

The standard test load was placed on the shelf at each of the four corners of the oven cavity to determine the effect of placement of the load on external power density levels, as shown in Table 8. Measurements were made with a Ramcor 1200B Densiometer. When the S-band horn was used, the long axis of the horn opening was horizontal. The point of measurement was at a height equal to that of the center of the cooking cavity and at a distance of 60 cm from the front of the oven. The oven door was completely open with the interlocks defeated.

Comparison of Power Density Meters

Three instruments, a Ramcor Model 1200B, a Narda B86B3 Hazard Hunter, and a Hewlett-Packard Model 431C Power Meter with a dipole antenna, were compared for their response to a microwave field in front of an

Table No. 7

Effect of Line Voltage on Microwave Power Densities, in mW/cm^2

Line Voltage	Litton* max.	Litton* min.	GE** max.	GE** min.	Sears*	Amana*	Tappan*
105/210	75	50	70	60	60	170	50
120/240	80	50	90	70	65	188	60
130/260	75	50	160	110	70	198	70

Some ovens were designated to operate with a line voltage of 120 V and some with a line voltage of 240 V so line voltage variation measurements were taken around the appropriate voltage.

** L-Band antenna
* S-Band antenna

Table No. 8

Measured Microwave Power Densities for Various Load Positions Within the Cavity, in mW/cm^2

Load Position***	Litton* max.	Litton* min.	GE** max.	GE** min.	Sears*	Amana*	Tappan*
Right rear	60	40	140	130	100	70	110
Right front	170	70	52	44	75	140	100
Left rear	150	75	56	51	75	160	110
Left front	30	6	54	52	125	185	110

** L-Band antenna
* S-Band antenna
*** Load position when facing front of oven

oven with the door completely open and the interlocks defeated. Attenuators were used with the Ramcor and Hewlett-Packard instruments to increase the meter range. (An attenuator cannot be used with the Narda Hazard Hunter.)

The results are shown on the succeeding graphs of measured power or power density as a function of distance. Although far field conditions are expected at distances beyond 30 cm from the open oven doors, the observed radiation power density decreased less rapidly than would be predicted from inverse square law calculations. Part of this effect may be caused by reflections from the chamber floor.

Dashed lines are shown in Figures 2, 3 and 4 as the envelopes of the observed maximum and minimum instrument readings. The shaded areas between the dashed lines represent the uncertainty of the measurements.

The use of attenuators with the Narda Hazard Hunter is not feasible, hence the upper range of measurement is limited, as shown in Figure 2. At 2450 MHz, the upper range limitation was 8.5 mW/cm^2.

The Ramcor Densiometer measurements, illustrated in Figure 3, show the difference in field intensity readings that result from changing the long axis orientation of the horn antenna from vertical to horizontal.

The data taken with the Hewlett-Packard 431C Power Meter, given in Figure 4, show different amounts of power with changes in antenna position. The discontinuities indicate points where a 10 dB attenuator

was inserted to increase the range of the instrument.

The use of a dipole antenna 6.12 cm long with a laboratory power meter (HP 431C Power Meter) allowed the widest dynamic range of the three types of instruments chosen for test, and gave the data most nearly approaching an inverse square law relationship of power with distance from 30 to 300 cm. The data were recorded in units of power, in milliwatts. To calculate power density in milliwatts per square centimeter, an effective antenna area must be assumed. Antenna area can be calculated from far field calibration data; however, these data were not available at the time of the tests.

The data taken with the dipole antenna show significant discontinuities where it was necessary to insert attenuators, and an intense standing wave pattern was observed. Part of this problem may result from the antenna impedance not being well matched to that of the coaxial signal transmission line. The coaxial cable may itself interact with the microwave field, altering its intensity and perhaps creating standing waves. Further, the response of the dipole antenna was sensitive to antenna orientation.

The use of the Ramcor Densiometer, with S-band horn antenna, resulted in data that did not resemble an inverse square law relationship of power density with distance. The standing wave pattern seemed in general less intense than that recorded with the dipole antenna and HP power meter. The response with the horn antenna was much more

sensitive to orientation than that of the dipole antenna. The manufacturer had calibrated the Densiometer, with the horn antenna, to read 0 decibels on the meter when exposed to a microwave power density of 10 mW/cm^2 in the far field at a frequency of 2450 MHz. The range of reading capability was 1 mW/cm^2 (-10 dB) to about 20 mW/cm^2 (+3 dB). With appropriate attenuators, the range can be increased about 100 fold.

The usefulness of the Narda Hazard Hunter was limited because of the low full-scale reading of 8.5 mW/cm^2 at 2450 MHz. The antenna was not noticeably sensitive to orientation. The readings, in mW/cm^2, approximately decreased as the inverse square of the distance from the center of the opening of the oven door, but were markedly lower than the equivalent readings made with the Ramcor Densiometer. At 100 cm distance, the Narda reading was 1/6th of the Ramcor; at 200 cm, 1/2 the Ramcor.

The size, shape, and effective area of the antenna seem to be critical calibration factors, probably contributing the most to orientation problems and lack of intercomparability for each of the three instruments that were compared. Close to the oven, particularly with the door almost closed, where each antenna might be partially irradiated with non-uniform, highly polarized fields, one would not expect instrument results to be comparable.

Figure No. 2

Power Density, in mW/cm^2, as a function of Distance, in cm.

Narda Hazard Hunter
Model B86B3

Frequency 2450 MHz

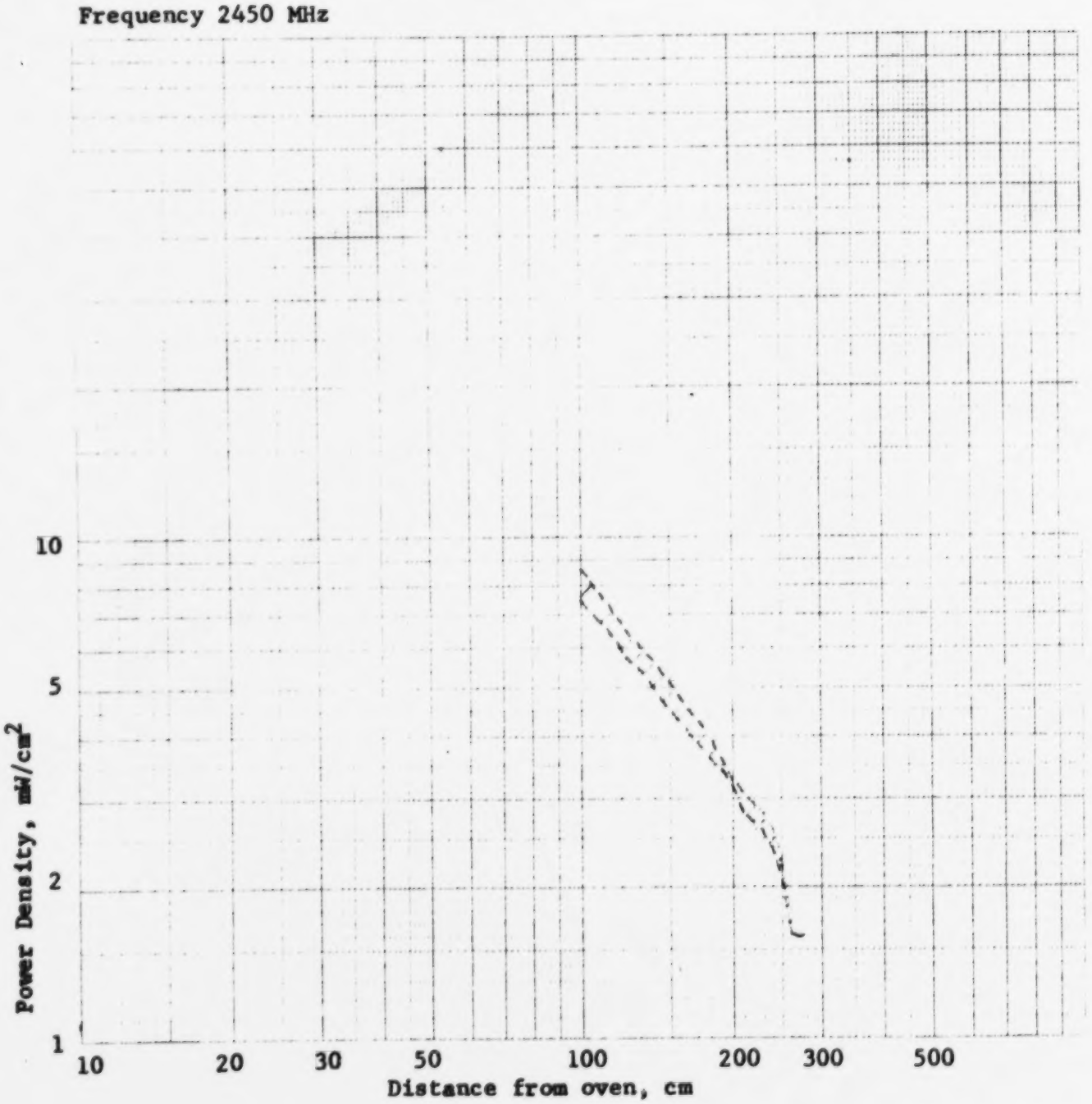
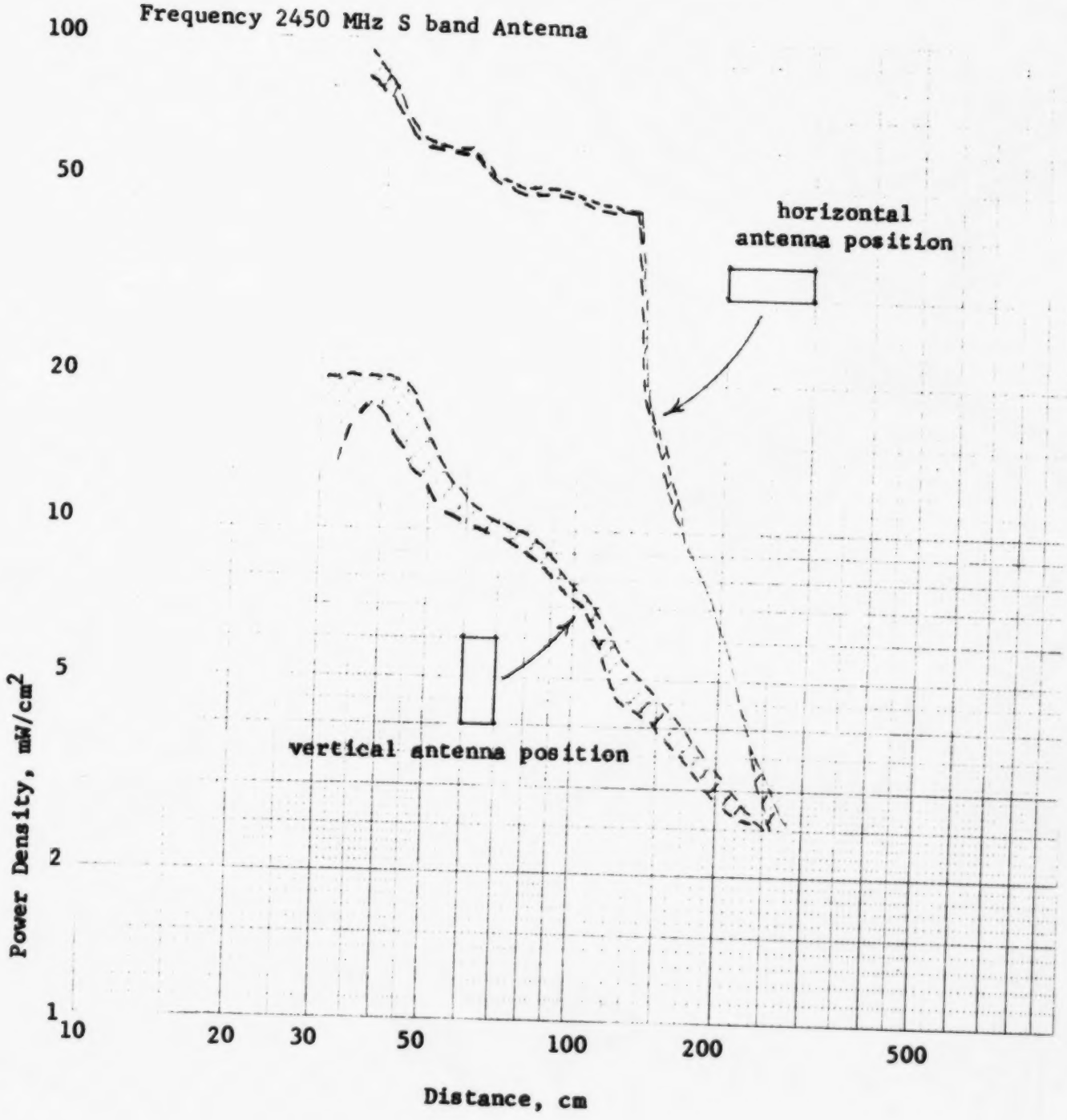


Figure No. 3

Power Density, in mW/cm^2, as a function of Distance, in cm.

Ramcor Densiometer Model 1200 B



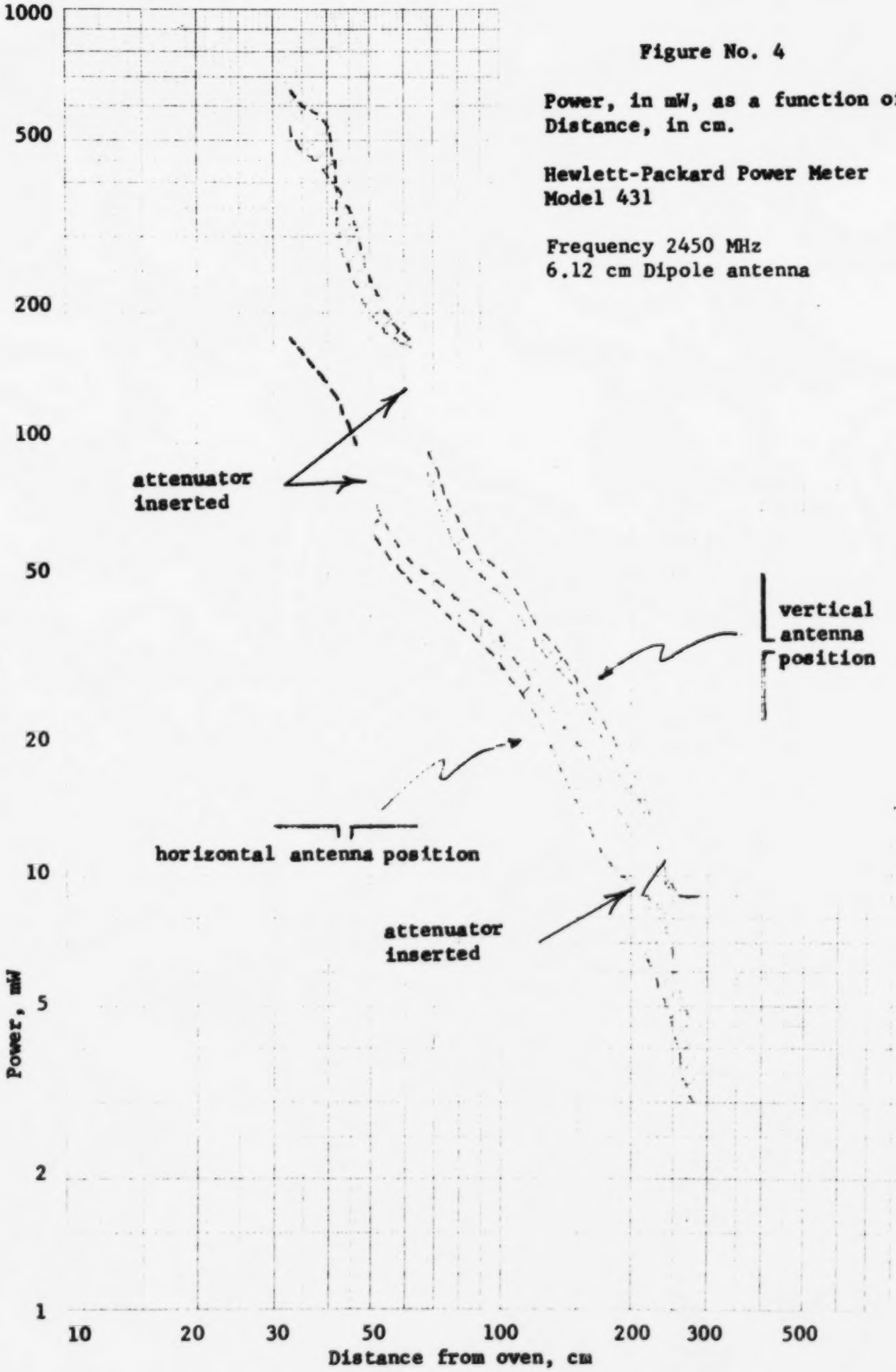


Figure No. 4

Power, in mW, as a function of Distance, in cm.

Hewlett-Packard Power Meter Model 431

Frequency 2450 MHz
6.12 cm Dipole antenna

DISCUSSION

The Federal Communications Commission has assigned frequencies of 13.56 ± 0.007, 27.12 ± 0.16, 40.68 ± 0.02, 915 ± 25, 2450 ± 50, 5800 ± 75 and 22,125 ± 125 MHz[5] to devices such as microwave ovens. Four of the ovens examined in this study operated at 2450 MHz, and one operated at 915 MHz, the only frequencies currently utilized by oven manufacturers. Survey instruments used for estimating microwave power or power density levels associated with oven operation must be designed and calibrated, therefore, for at least the latter two frequencies. Three commercially available instruments were compared, using the microwave ovens as sources of microwave power:

	Instrument Type	Frequency MHz	Antenna Type	Calibration Factor
1)	Hewlett-Packard Power Meter Model 431C Range .1 μW to 10 mW, extended with attenuators	2450	Dipole, 6.12 cm	Unknown
2)	Ramcor Densiometer Model 1200B Range -10 dB to +3 dB 0 dB = 10 mW/cm^2 in far field, extended with attenuators	2450 915	S-Band Horn L-Band Spiral	1.00 1.00
3)	Narda EM Radiation Monitor Model B86B3/B7 Range 1 mW/cm^2 to 20 mW/cm^2 modified by calibration factor	2450 915	Slotted Plane Slotted Plane	0.425 0.748

The three instruments have different types of antennae, and, therefore, they differ in directivity, orientation sensitivity, effective antenna area, front-to-back ratio, efficiency, standing wave ratios, and useful

ranges of sensitivity. Even when they are identically calibrated in the far field, one could not expect them to read identically under all conditions of exposure.

When an open oven operating at 2450 MHz was used as the source of microwave radiation, the Hewlett-Packard power meter with dipole antenna indicated that microwave power levels, as detected by the antenna, decreased approximately as the inverse square of the distance from the door opening, from 30 to 300 cm. The dipole power reading taken with the dipole vertical at each location was added to that taken with the dipole horizontal. These sums were fitted to a smooth power function, and were found to fit the formula $P = 0.09/D^2$, where P was the sum of indicated powers in Watts, and D was measured in meters from the center of the plane of the oven door opening. The radiation field seemed sufficiently homogeneous to warrant its use to compare the readings of the Narda and the Ramcor survey instruments. The dipole antenna did indicate the presence of some standing waves, and about 1.5 to 3 times as much power was detected with the dipole vertical as with it horizontal.

Comparisons made with the Narda instrument were limited by the lack of range of the instrument. The Narda had been calibrated by the manufacturer to read in mW/cm^2. By dividing the dipole power readings by the Narda's readings in power density, an apparent area, in cm^2, for the dipole antenna may be obtained. For corresponding measurements made at distances of 100 to 250 cm, the apparent dipole antenna area

calculated from Narda readings seemed to change from 6.80 to 11.25 cm^2, varying by a factor of 1.3 about a median of 8.8 cm^2.

The same calculation was done, comparing the Ramcor Densiometer readings, taken with the S-band horn antenna, with the dipole antenna results. Values for the apparent dipole antenna area varied from as low as 1.64 cm^2 at 100 cm, to 6.73 cm^2 at 35 cm. The apparent area calculated from Ramcor readings varied by a factor of 2 about a median of 3.3 cm^2.

The Ramcor read higher than the Narda by an average factor of 3.9 over the distances where both could be compared. The ratio at times, however, was as great as 6.9. The variation in response may be caused by fundamental differences in calibration, as well as by basic differences in survey meter response in the radiation field in which they were compared.

There appears to be no basic reason for choosing one type of survey instrument in preference to another. From safety considerations for both operator and surveyor, however, the instrument giving the highest reading should be used until the uncertainty is resolved. Since instrument readings for an instrument were fairly reproducible, it should eventually be possible to determine the power densities that actually existed at the various locations. The Ramcor Densiometer, a portable instrument with a relatively small directional antenna that has a relatively wide range of sensitivity, was selected for the

comparative measurements of external microwave fields produced by the test ovens.

The observations made at NCRH on microwave ovens operating at 2450 MHz demonstrated that power density levels which measured above 700 mW/cm^2 could be produced if the door safety devices failed or were bypassed. Under such conditions a separation of 4 feet between a person and the open door was often insufficient to bring the power density levels down to 10 mW/cm^2. Tests which were performed with plastic strips in the oven door seal, a situation simulating accidental jamming or failure of sealing, revealed leakages near the door edges, some of which were 10 mW/cm^2 or greater when measured with the instrument 5 cm from the door. Leakages much higher than 10 mW/cm^2, measured under field conditions, have been reported by Suroviec, Breysse and others. For the ovens tested, interlocks designed to protect both operator and serviceman, varied from one to three in number, and the effort involved in bypassing them varied from great to slight. In no case was it felt that a truly fail safe design had been achieved by the manufacturer.

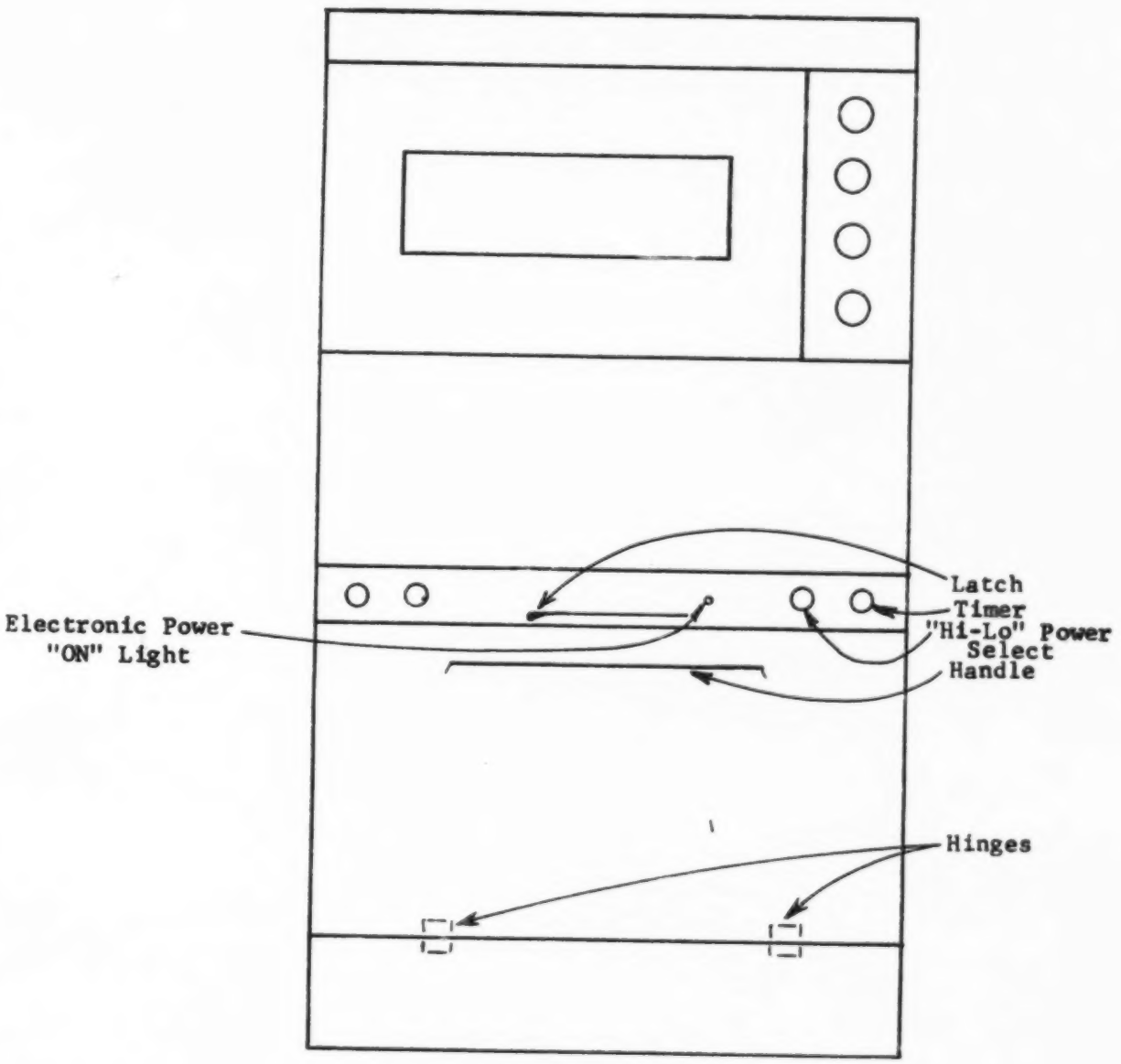
Changes in load placement within the oven cavity or changes in power line voltage were shown to produce variation by a factor of 2 or 3 in the power density levels that were measured under "standard" conditions. Similar variations in apparent power density were seen, also, when different commercial types of measuring instruments were compared under seemingly identical conditions. These findings show that exact determinations of microwave oven leakage are very difficult to make near the oven.

An improperly functioning oven can be a potentially hazardous appliance because people naturally look into an oven when opening it to visually examine food. Also, they may place their hands in the oven to insert and remove food, and to clean the oven. Therefore, a possible microwave exposure condition would exist for anyone opening an oven with inoperative door safety interlocks. The only indication that the person would have to warn him of a potentially hazardous condition would be the possible warming of his face or hands.

APPENDIX 1

Sketches and Specifications of Microwave Ovens

APPENDIX 1



GENERAL ELECTRIC AMERICANA "VERSATRONIC"

Manufactured by

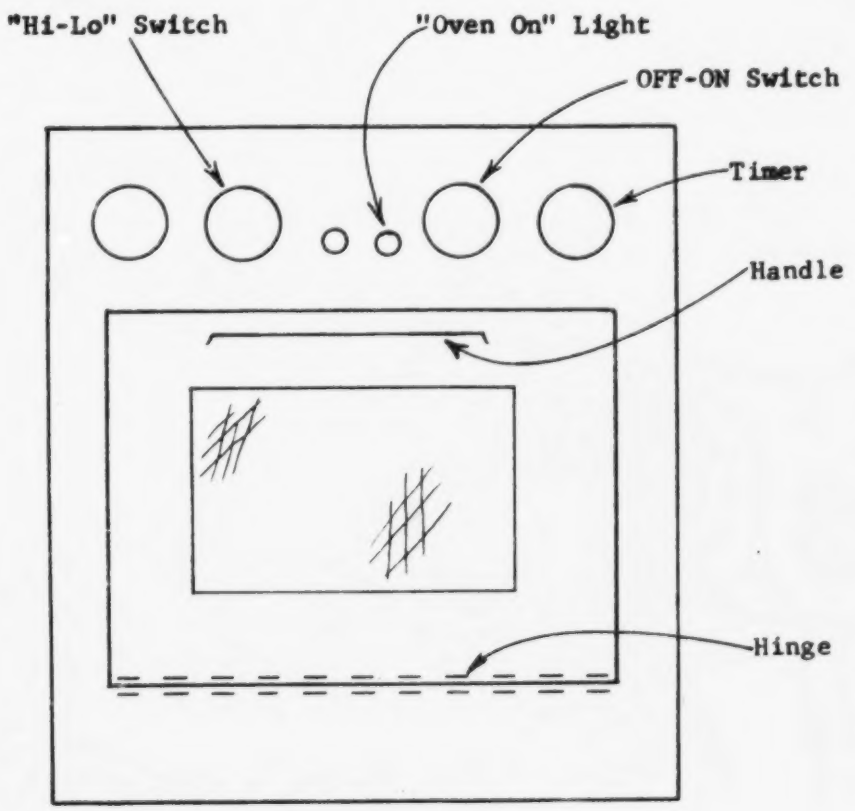
General Electric Co.
Louisville, Kentucky

Model number JE896D1AV

Serial number MDE02642

Operating frequency 915 MHz

Cavity: H 37.5 cm, W 53.5 cm, D 49 cm



TAPPAN ELECTRONIC

Manufactured by*

Tappan Co.
Mansfield, Ohio

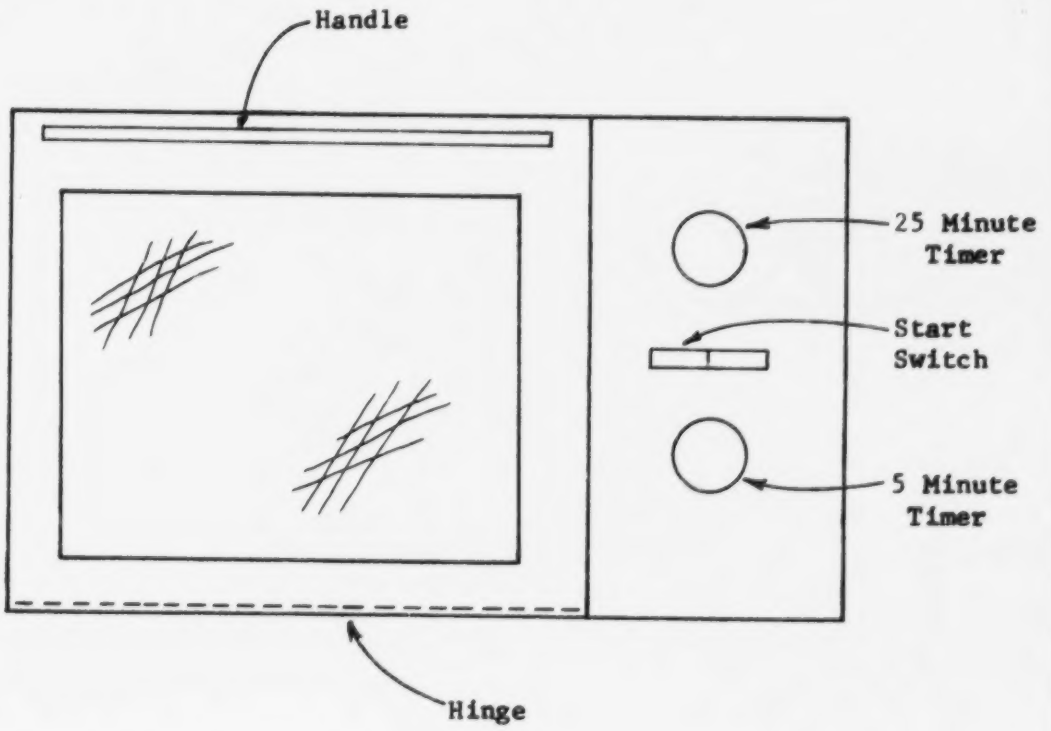
Model number R-4A lot 4

Serial number 04190-1828-2590

Cavity: H 31 cm, W 46 cm, D 35.5 cm

* Electronics by Litton Industries

Operating frequency 2450 MHz



AMANA "RADARANGE"

Manufactured by

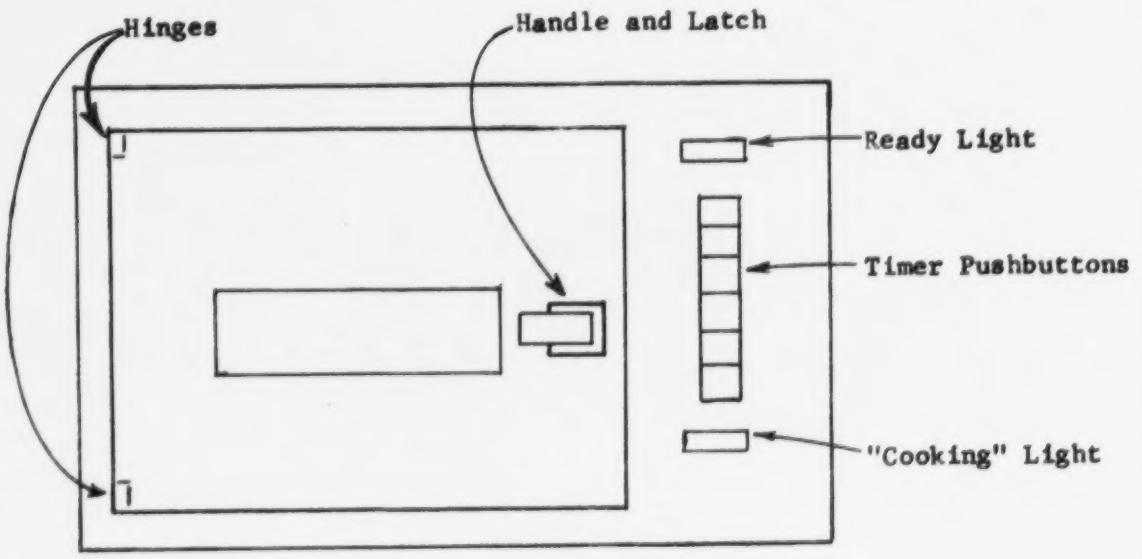
Amana
Amana, Iowa

Model number RR-1

Serial number R18354082

Operating frequency 2450 MHz

Cavity: H 30 cm, W 37 cm, D 38 cm



LITTON MICROWAVE OVEN

Manufactured by

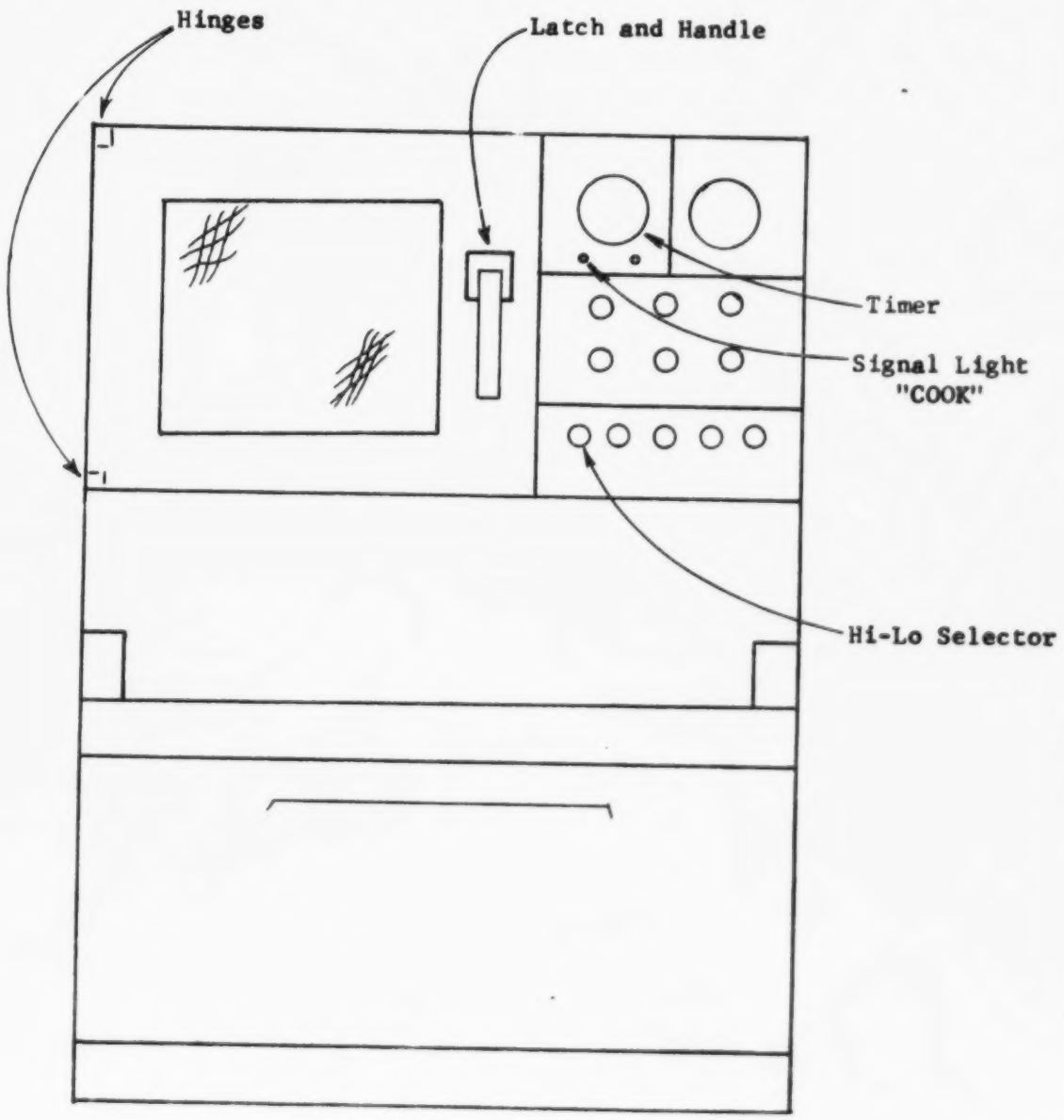
Litton Industries
Atherton Division, Minneapolis, Minnesota

Model number 500.015 FJ

Serial number 24058

Operating frequency 2450 MHz

Cavity: H 20.5 cm, W 30.5 cm, D 32 cm



SEARS KENMORE "ELECTRONIC" 994

Manufactured by

Roper
Kankakee, Illinois

Model number 103.9946700

Serial number 7268160

Operating frequency 2450 MHz
Cavity: H 29 cm, W 39 cm, D 37 cm

APPENDIX 2

Microwave Anechoic Chamber

The anechoic chamber is an open-ended, tapering plywood box 6.1 meters long. The closed, small end, is approximately 2.4 meters wide x 3.5 meters high and the large end, which is open, is approximately 4.9 meters wide x 3.5 meters high. The walls, small end and ceiling are lined with a rigid foam microwave anechoic material (ECCOSORB CV-B24F). The bare plywood floor is supported one inch above the concrete floor. The open end of the chamber is approximately 10 meters from the end of the room.

The anechoic chamber is located in a room 20 feet wide, 60 feet long and 12½ feet high. Two 20 x 12½ foot walls and one 60 x 12½ foot wall are exterior building walls of concrete block construction. The remaining wall is a 2 x 4 inch stud partition covered with 3/8 inch plywood to a height of 8 feet. The floor is a concrete slab on grade. The ceiling is exposed corrugated metal supporting light weight aggregate with a tar and gravel finish. The windows and the 60 foot long interior wall were covered with aluminum screen wire. The 12½ foot high by 20 foot long wall opposite the open end of the chamber was covered with ECCOSORB CV-B24F.

APPENDIX 3

Materials and Equipment

1) Ramcor Densiometer
   Model No. 1200B
   Manufactured by Ramcor, Inc.
   270 East Pulaski Road
   P. O. Box 671
   Huntington, Long Island, New York 11743

   2300-3950 MHz S Band Horn Antenna
   800-1800 MHz L Band 'Spiral' Antenna

2) NARDA Electromagnetic Radiation Monitor
   Model B86B3/B7
   Manufactured by NARDA Microwave Corporation
   Plainview, Long Island, New York 11803

3) Hewlett-Packard Power Meter
   Model 431C
   Manufactured by Hewlett-Packard Company
   1501 Page Mill Road
   Palo Alto, California

4) General Radio "Variac" Type 50B
   Manufactured by General Radio
   Cambridge, Massachusetts

5) 1/2 wave dipole - overall length 6.12 cm soldered to end of RG58 coaxial cable.

6) NARDA Model 757B, 10 dB Coaxial Attenuator
   See 2 above.

REFERENCES

1. Suroviec, Henry J., Microwave oven radiation hazards in food vending establishments, Arch. Environ. Health, 14, 469 (1967).

2. Breysse, Peter A., Microwave cookers, Journal of Environmental Health, 29, 144 (1966).

3. Hearings before the Committee on Commerce, United States Senate, on the Radiation Control for Health and Safety Act of 1967. Part 2, May 1968. Serial No. 90-49. U.S. Gov't. Printing Office.

4. An Annotated Bibliography of Regulations,Standards and Guides for Microwaves, Ultraviolet Radiation and Radiation from Lasers and Television Receivers. U.S. Dept. of Health, Education, and Welfare, National Center for Radiological Health, Rockville, Maryland.

5. Federal Communications Commission Rules and Regulations, Volume II, Part 18, Industrial, Scientific, and Medical Equipment.